Acquisition of the Magnetometer for Magnetic Field Research and Education.

Zbigniew Celinski, University of Colorado at Colorado Springs, DMR Award #0114189

A most important result of our current NSF award was the improvement of our research infrastructure. We purchased a SQUID magnetometer manufactured by the Quantum Design. With this purchase we significantly enhance our magnetic laboratory since now we can produce magnetic structures using Molecular Beam Epitaxy (MBE), UHV e-beam evaporator, or sputtering system. We can study their dynamic magnetic properties with a series of Ferromagnetic Resonance (FMR) spectrometers (10, 24, 35, 45, and 55 GHz) and Brillouin Light Scattering (BLS) system. The static magnetic properties we investigate using a Magneto-Optical Kerr Effect (MOKE) and currently with SQUID magnetometer. Moreover, we have a magneto-transport measurement (GMR) system. Such equipped laboratory places us in a unique position among U.S. undergraduate institutions. The above mentioned equipment is used not only for the sponsored research but also in our Solid State Physics Laboratory and Thin Film Laboratory courses. The SQUID magnetometer was delivered in end of May 2002 and up to now we have submitted 2 publications to the Journal of Applied Physics using results from this new system.

Using SQUID magnetometer and 24 GHz FMR spectrometer we studied a new type of exchange biased structure (Fe/KCoF3), grown by MBE. We found a significant enhancement of four-fold anisotropy at low temperatures in the samples with polycrystalline KCoF3 structure (see Figure 1). Magnetization measurements below 115 K showed a hysteresis loop shift of due to exchange bias (Fig. 2).

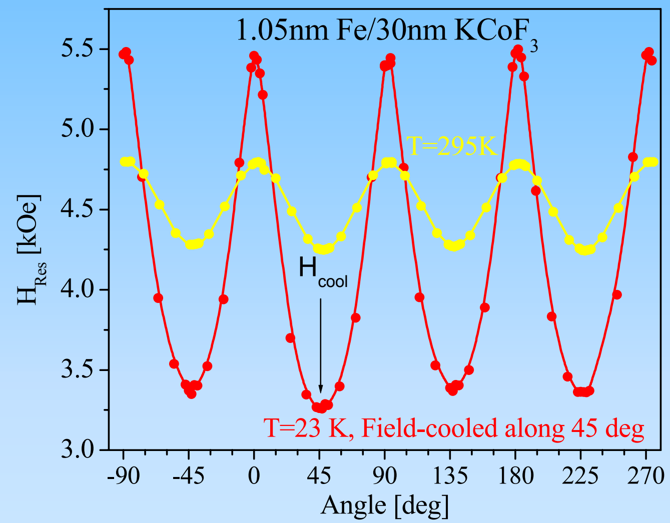

Figure 1 Resonance field as a function of the angle between the applied magnetic field and the [110] axis for $T = 24$ K and $T = 295$ K. The sample is zero-field cooled and has polycrystalline fluoride and a thickness of 1.05 nm Fe.

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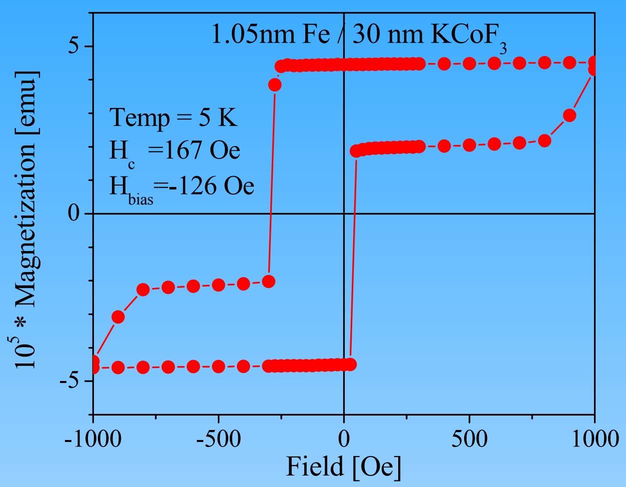

Figure 2 Shifted Hysteresis loop measured.

Using the SQUID magnetometer we studied also arrays of ultra-small magnetic dots, 10 nm in diameter, 6.5 nm height, and an average separation between dot centers of 22 nm. The dot locations are determined by the biological mask that is used to create ordered arrays of ~4 nm deep holes in Si. SQUID data showed that these objects are magnetic even at room temperature and are fairly soft with a coercive field of ~100 Oe and magnetization in plane.

<u>Educational:</u>
2 high school students, 3 undergraduate students
2 research associates (PDF)
The mentioned above personnel worked at least part time on SQUID magnetometer, receiving training in SQUID operation.

<u>Collaborators:</u>
R. Goldfarb, T. Silva, NIST, Boulder
D. Skrzypek, University of Silesia, Katowice, Poland
L. Wee and R. Stamps, UWA, Perth, Australia
C. Schneider, IFW, Dresden, Germany

<u>Brief summary of outreach activities:</u>
the PI mentored two high school students working in the lab each summer – the REAP program

Jennifer Giles, an undergraduate students prepares a sequence of measurements on SQUID magnetometer.